



Targetry Program in the US

NUFACT'03

Columbia University

June 7, 2003



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Brookhaven National Laboratory

Interest in High-power Proton Drivers

High average power—SNS

- Thermal management
- Radiation damage

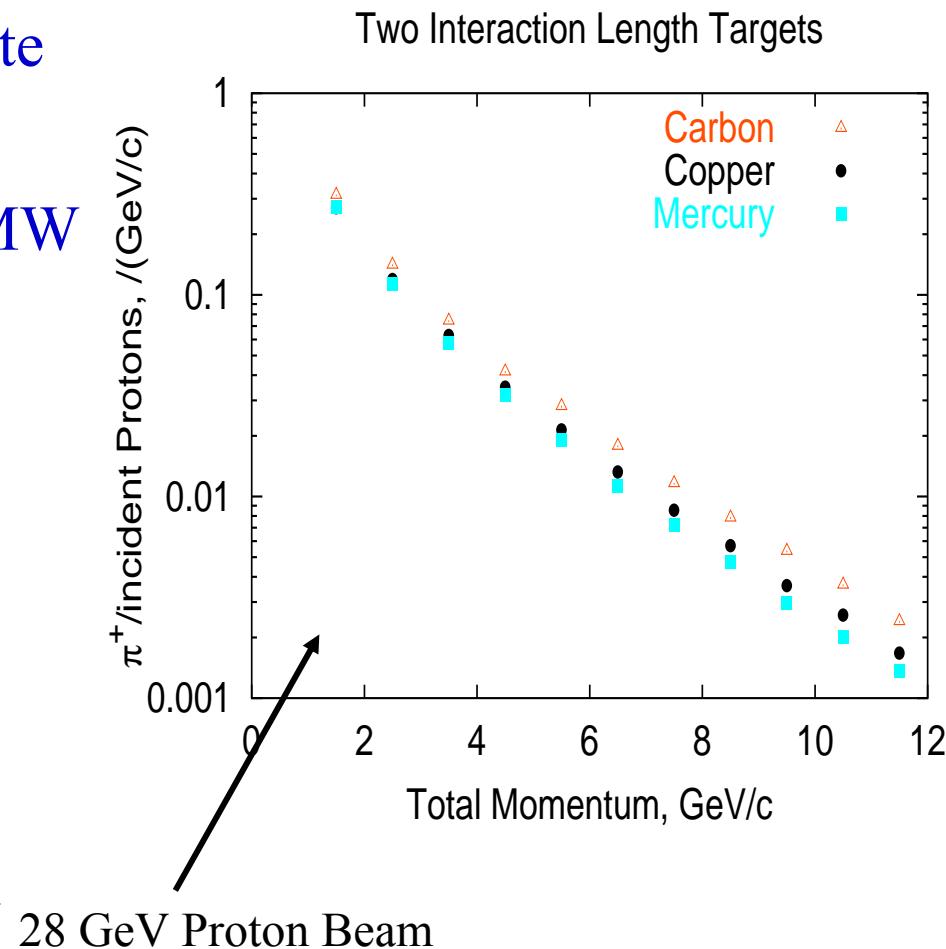
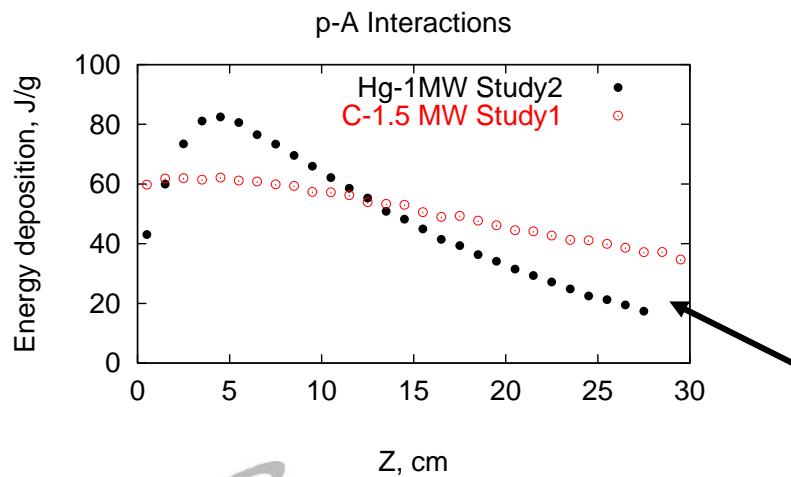
High peak power—NLC, Superbeams, Nufact

- Thermal management
- Radiation damage
- Thermal shock

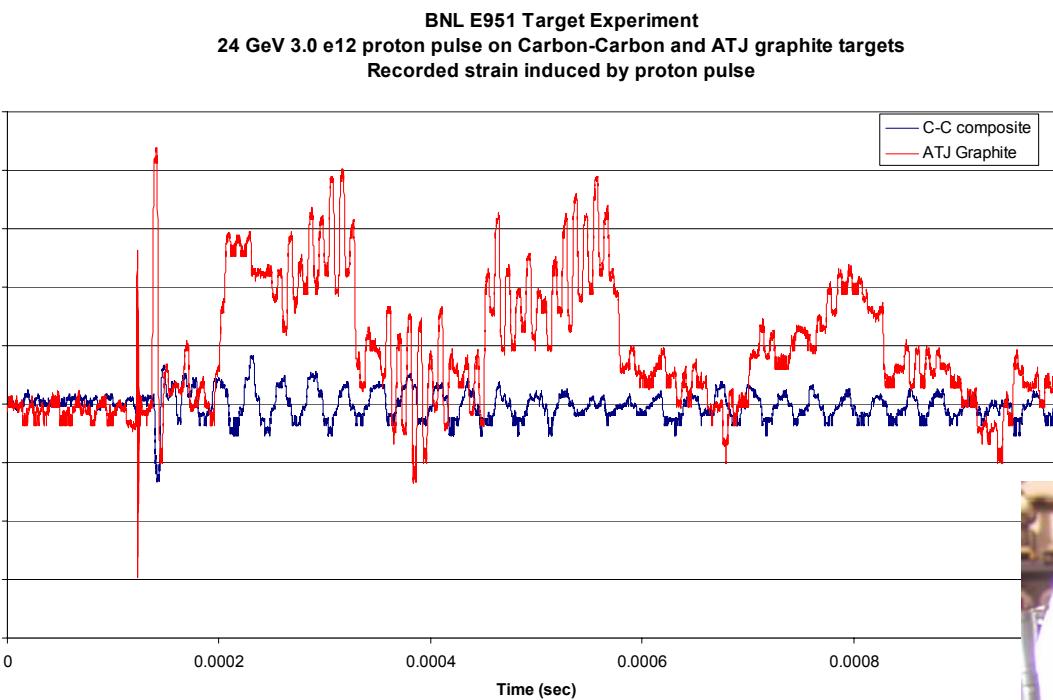
Superbeams

Carbon is a good target candidate

- Higher momentum pions
- Stationary target up to 1.5 MW
- Good thermal properties
- Low energy deposition densities

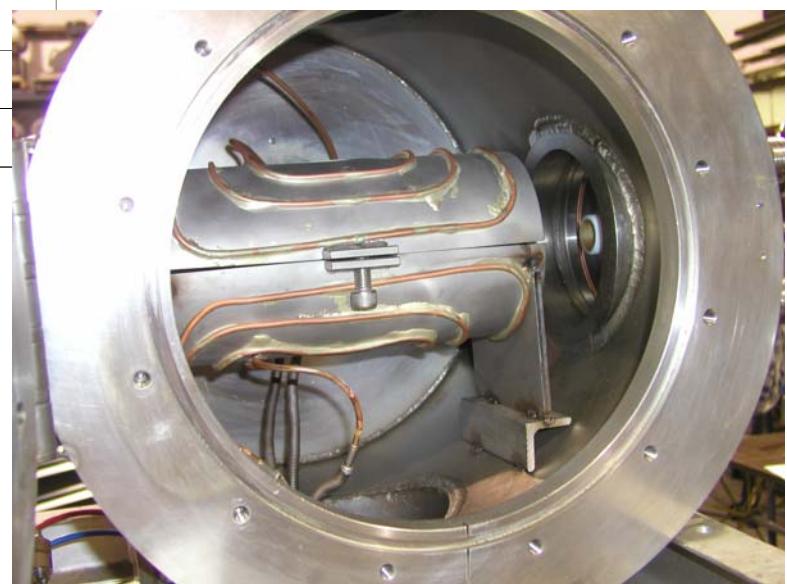


Carbon Studies



E951 Results:
Carbon-Carbon strains
significantly less than
for ATJ Carbon

ORNL Studies—J. Haines, et al.
Carbon sublimation tests at 2000° C

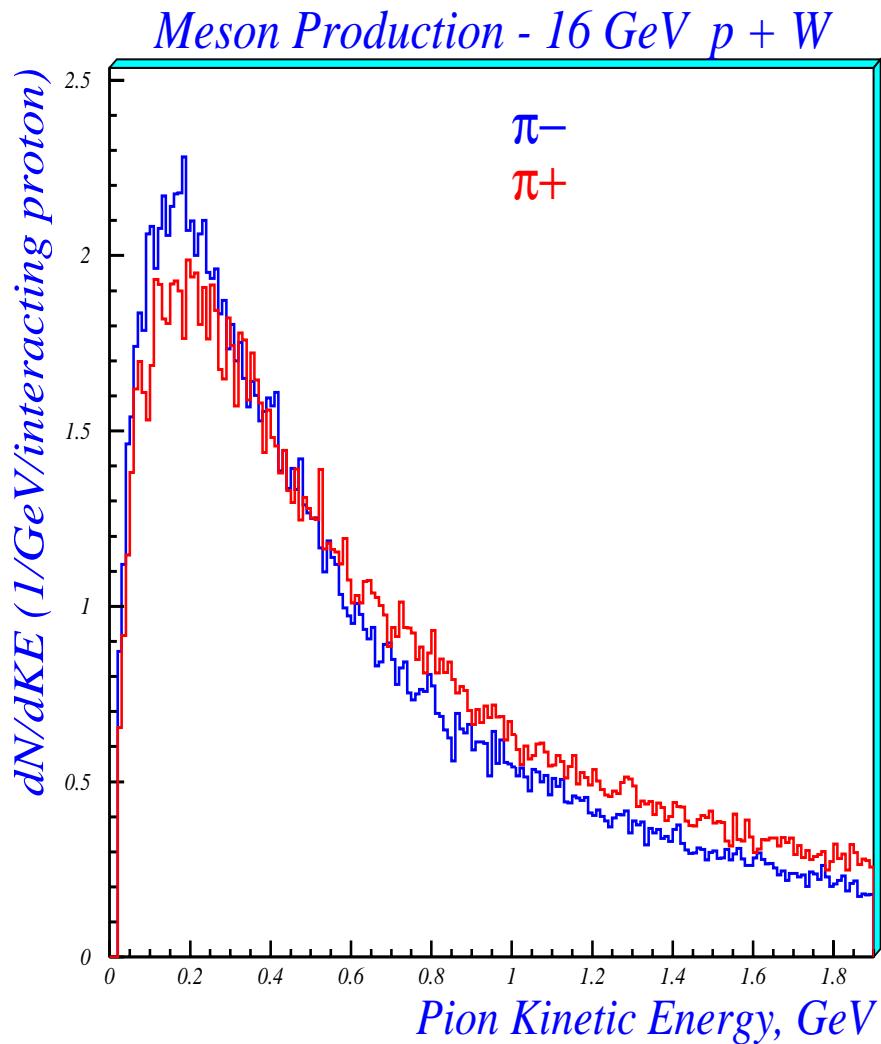
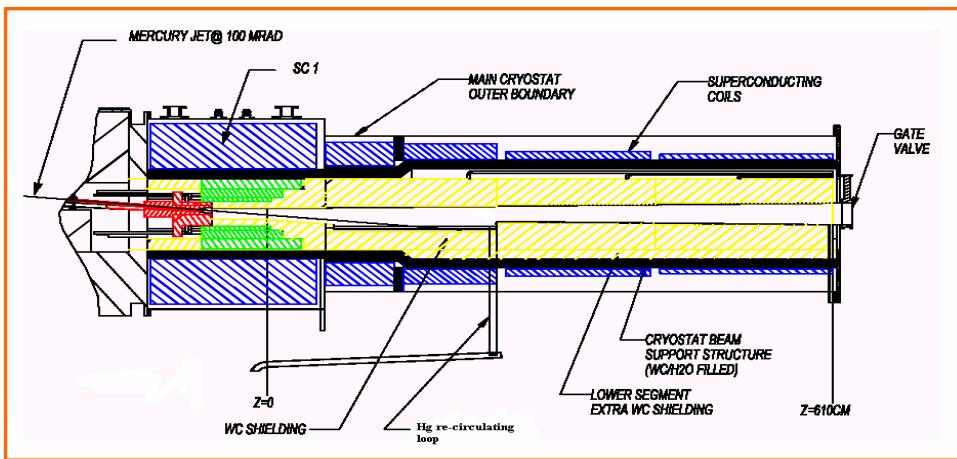


Harold G. Kirk

Neutrino Factory

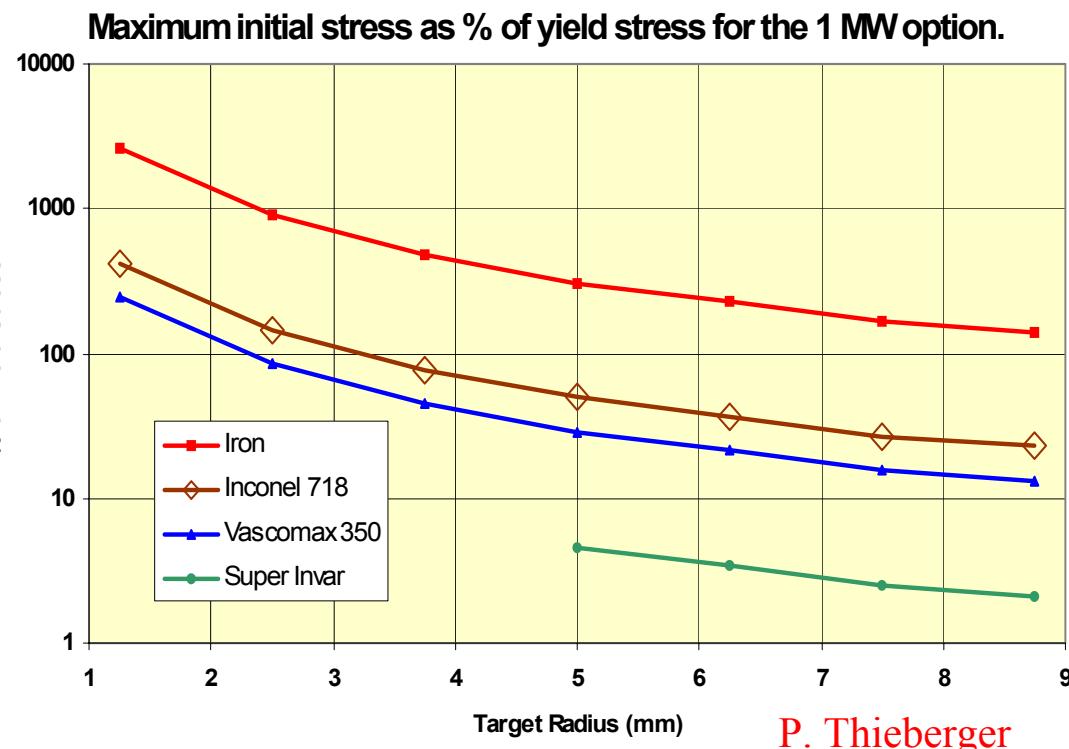
Maximize Pion/Muon Production

- Soft Pion Production
 - Higher Z material
 - High energy deposition
 - Prone to target dissipation
- High Magnetic Field



Mid-Z Iron Based Alloys

Iron alloys are interesting based on either their high yield strengths or their low Coefficient of Thermal Expansion (CTE) properties.



- Iron

- Yield strength—170 Mpa
- CTE— $12.5 \times 10^{-6} / {}^\circ\text{K}$

- Inconel

- Yield strength—1034 Mpa

- Vascomax

- Yield strength—2242 Mpa

- Super-invar

- CTE— $0.5 \times 10^{-6} / {}^\circ\text{K}$

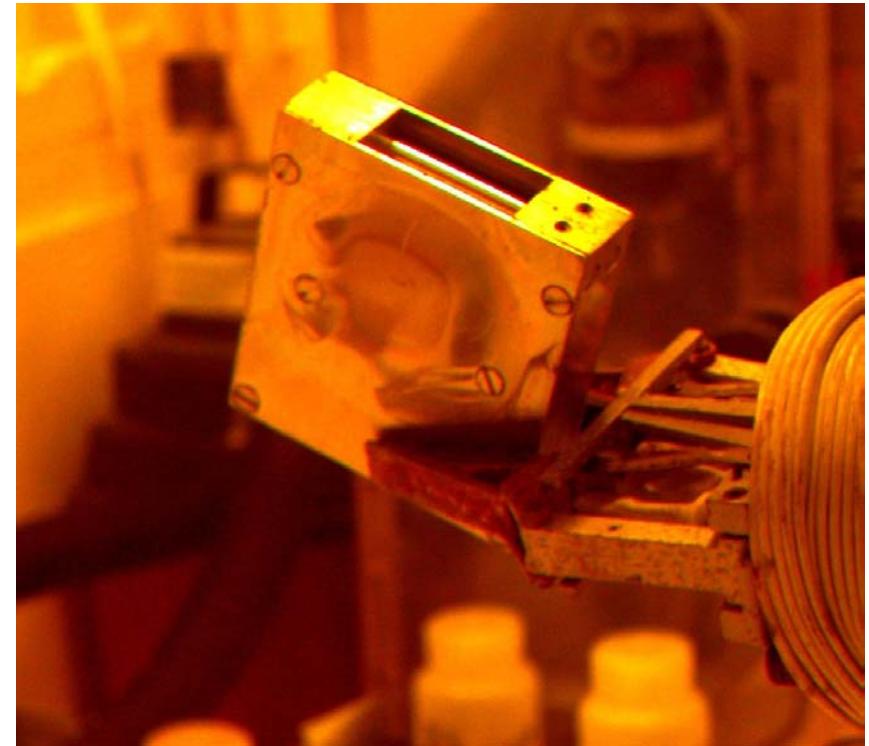
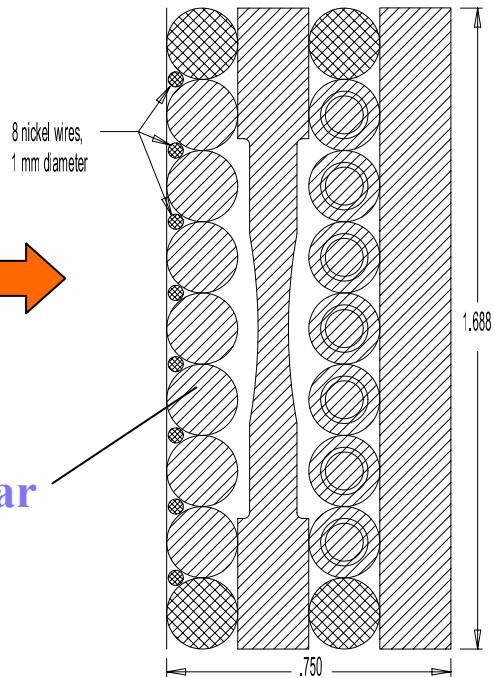
BLIP Irradiation Tests

- 1 ½ weeks running
- 200 MeV protons
- 5×10^{20} protons on target

Proton Beam



Super-Invar

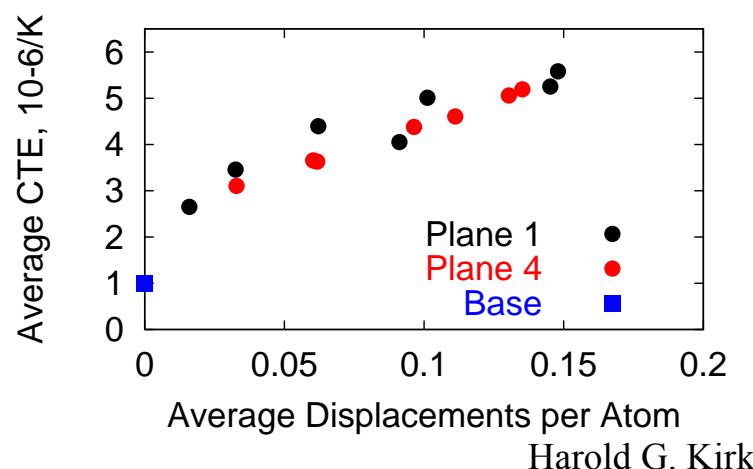
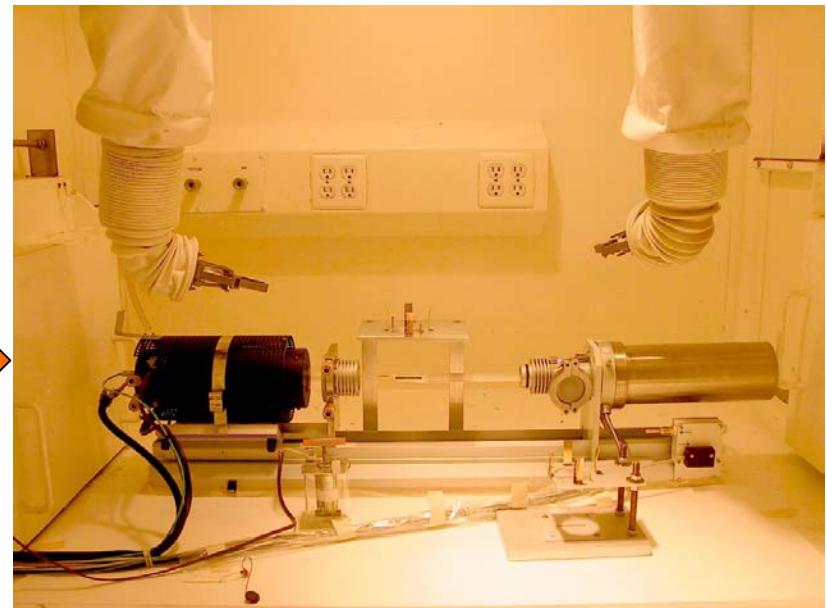
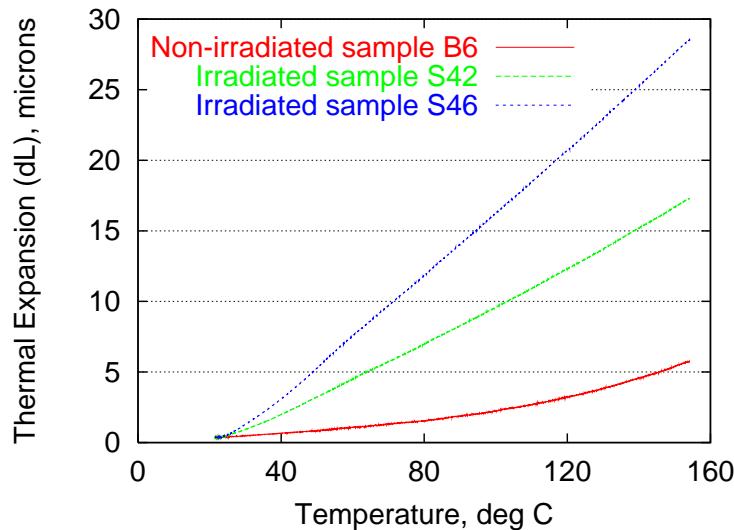


Target Holder After Irradiation
24 Rads at 2m

Thermal Expansion Measurements

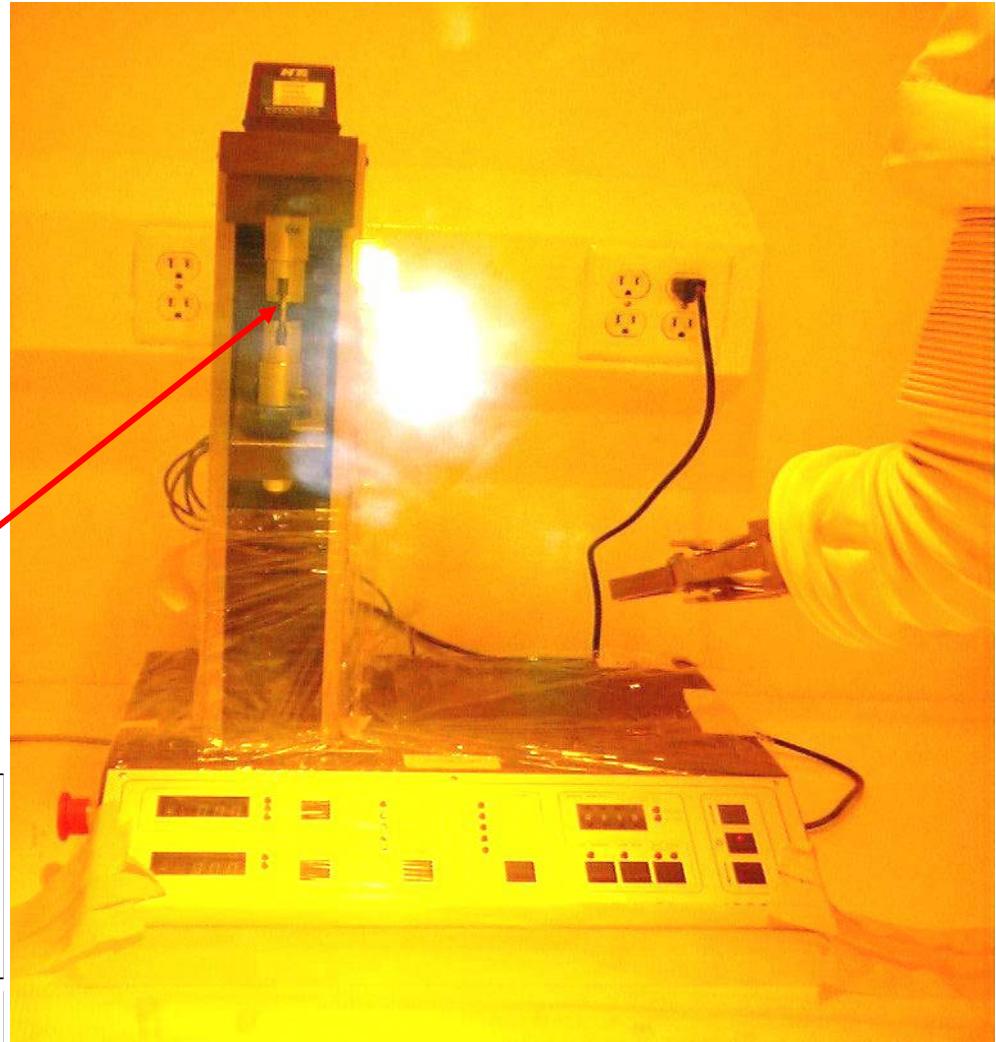
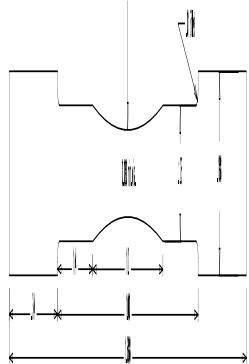
We find that the Coefficient of Thermal Expansion (CTE) of super-invar is sensitive to the level of irradiation exposure.

Dilatometer within the hot cell

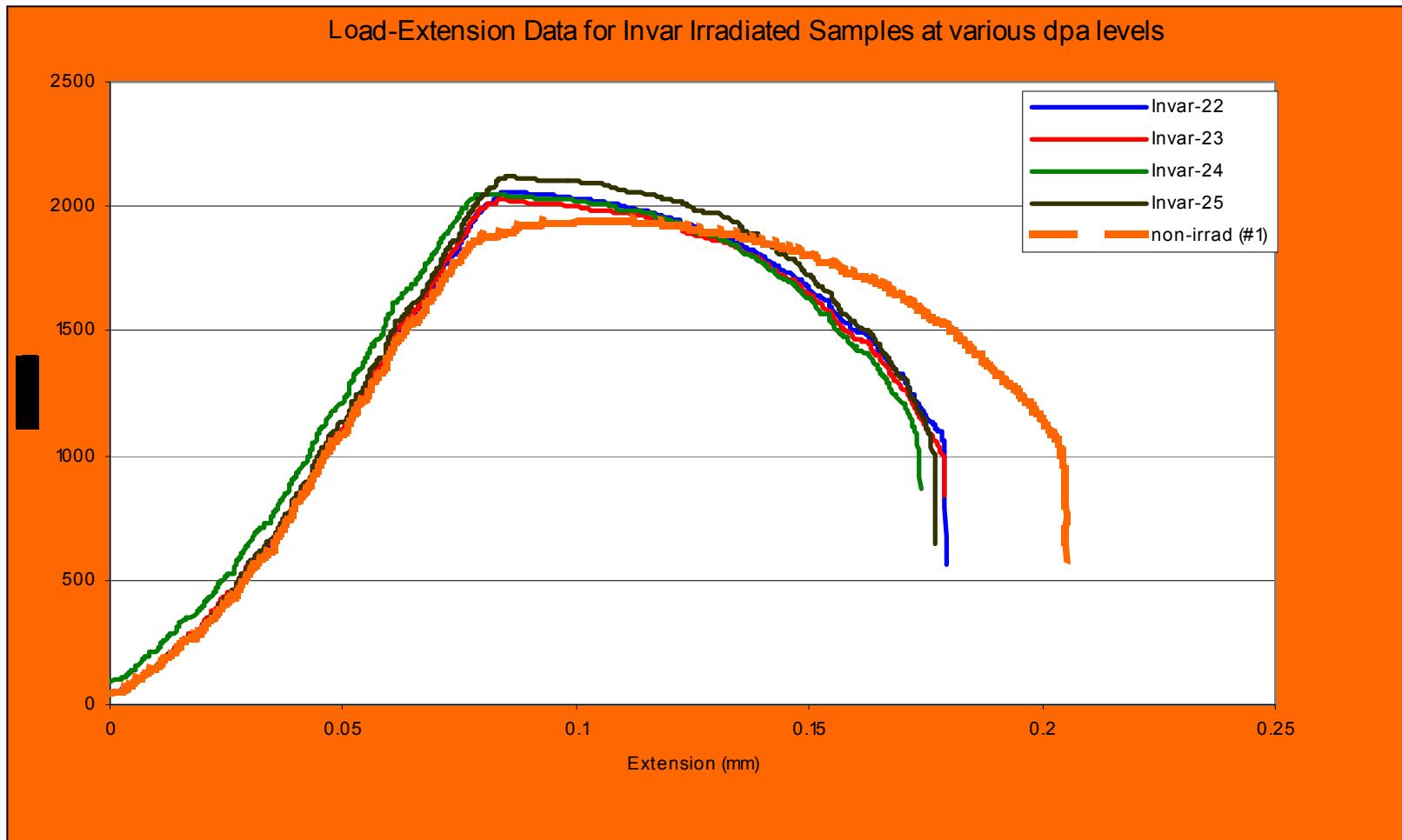


Load-Extension Tests

We placed a
Tinus-Olsen
Tensile Tester
inside the hot cell
in order to
measure the
mechanical tensile
properties of the
irradiated super-
invar samples.



Yield Strength Measurements



High-Z Materials

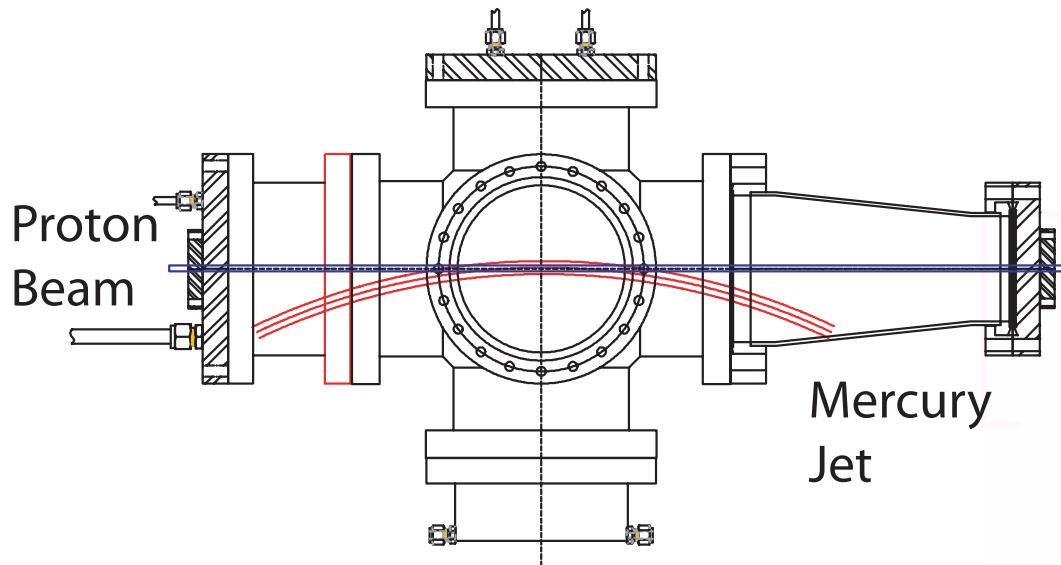
Key Properties

- Maximal soft-pion production
- High pion absorption
- High peak energy deposition
- Potential for extension beyond 4 MW (liquids)

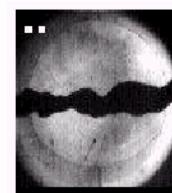
Key Issues

- Jet dynamics in a high-field solenoid
- Target disruption
- Achievement of near-laminar flow for a 20 m/s jet

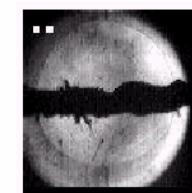
E951 Hg Jet Tests



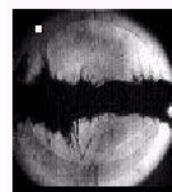
- 1cm Diameter Hg Jet
- 16 GeV 4 TP Proton Beam
- No Magnetic Field



$t = 0 \text{ ms}$



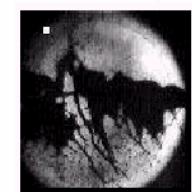
$t = 0.75 \text{ ms}$



$t = 2 \text{ ms}$

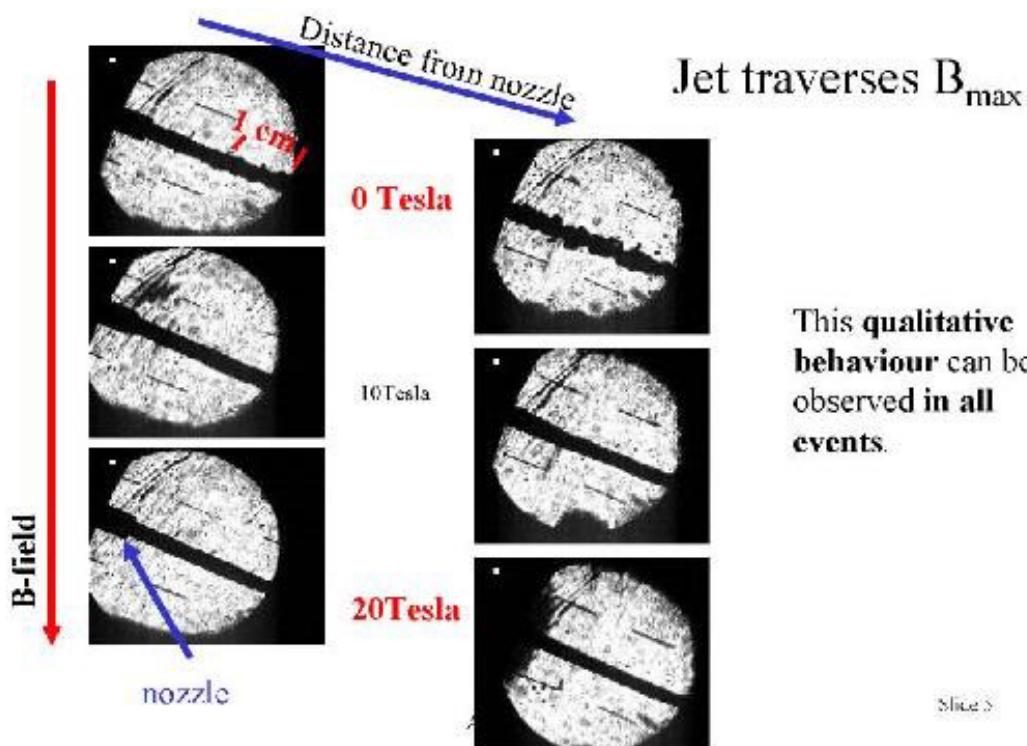


$t = 7 \text{ ms}$



$t = 18 \text{ ms}$

CERN/Grenoble Hg Jet Tests

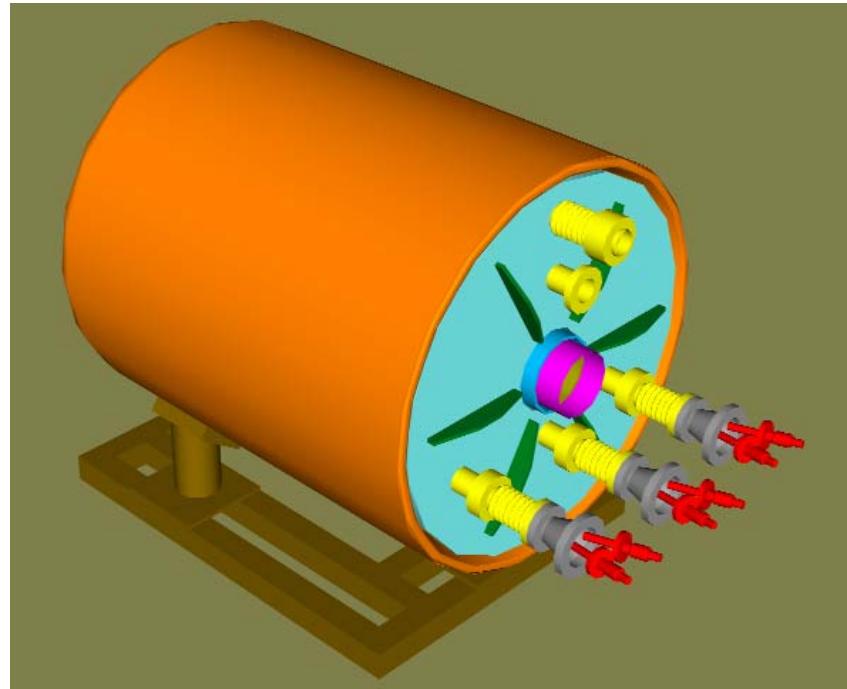
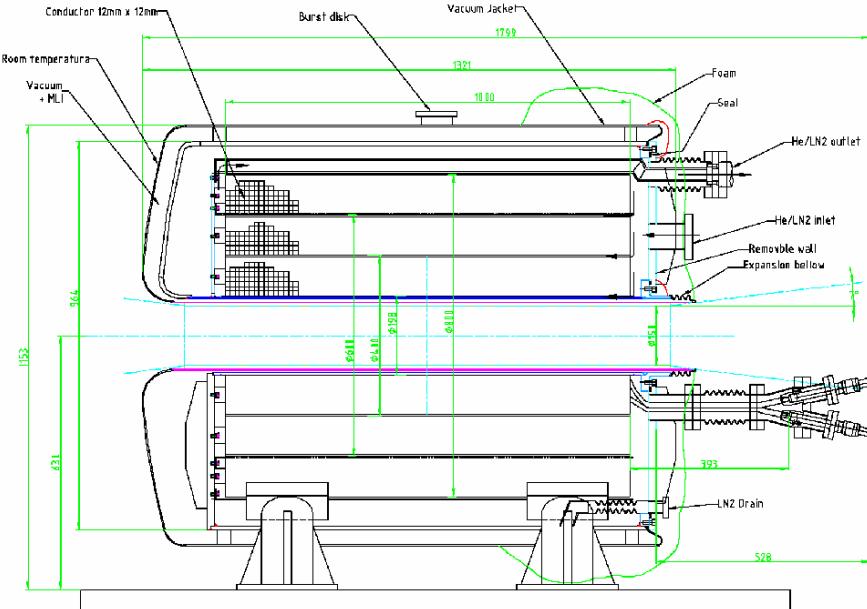


- 4 mm Diameter Hg Jet
- $v = 12$ m/s
- 0, 10, 20T Magnetic Field
- No Proton Beam

A. Fabich, J. Lettry
Nufact'02

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High Field Pulsed Solenoid



- 70° K Operation
- 15 T with 4.5 MW Pulsed Power
- 15 cm warm bore
- 1 m long beam pipe

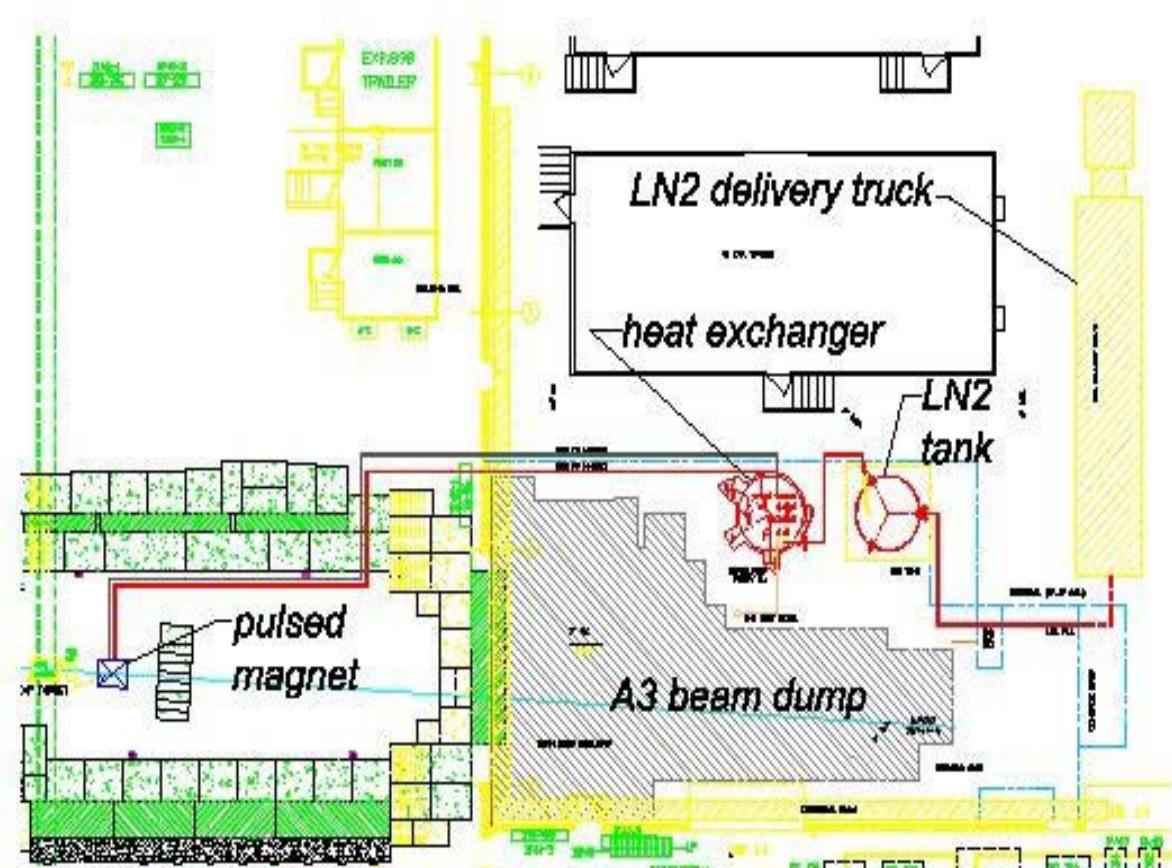
Peter Titus, MIT

Future E951 Running

We plan to resume E951 running at the AGS.

But DOE HEP support has been terminated for FY03 and will likely remain so for FY04 and FY05.

We need to explore alternatives.



Alternative Running

Alternatives for targetry running:

Parameter	BNL AGS	CERN PS	JPARC RCS	JPARC MR
Proton Energy, GeV	24	24	3	50
p/bunch, 10^{12}	8	4	40	40
p/cycle, 10^{12}	70	30	80	300
Cycle length, μs	2.2	2.0	0.6	4.2
Availability (?)	07	06	07	08